INSTRUCTION MANUAL

MODEL 304T(TD)
TRACKING
WAVE AND SPECTRUM ANALYZER

FOR SERIAL NO. 163

Quan-Tech®
Div. of KMS Industries, Inc.

Specialists in Electronic Instrumentation

43 South Jefferson Road Whippany, New Jersey 07981
Telephone: (201) 887-5508

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CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Quan-Tech Division KMS Industries, Inc. warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electronic tubes and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misadjustments, misuse, or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

Calibration checks of this instrument can easily be made in accordance with the instruction manual. Routine readjustments **should never** be attempted. If, however, the instrument has been damaged and requires recalibration or alignment, explicit calibration procedures as defined in the instruction manual **must** be followed.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory. If requested an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

The instruments should be packed in their original containers, or in a strong exterior container and surrounded by two inches of shock absorbing material.

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A. DESCRIPTION

The Model 304T(TD) is a multi-purpose instrument. It is not only useful as a precision wave analyzer for harmonic measurements and Fourier analysis of complex signals, but its three selectable flat-top bandwidths make it ideally suited for spectral density analysis of random signals.

The Model 304 features electronic tuning, using a stable voltage controlled oscillator. A 5000 division linear scale is provided for manual tuning. The 304T(TD) (digital) offers a five digit display (i.e. resolution to 0.1 Hz). A six position MODE switch controls the tuning functions of the Model 304T(TD). In the OFF position the instrument acts as a normal, manually tuned wave analyzer. In the OFF position the instrument acts as a normal, manually tuned wave analyzer. In the AFC position the Analyzer will track a drifting signal and follow it over a limited frequency range determined by the bandwidth. In the TRACK position, the instrument will lock onto a signal and follow it over the whole or discrete portions of the tuning range. In the SWEEP position, the Analyzer will start at the frequency to which the tuning dial is set, and scan upward in frequency over the whole or discrete portions of the tuning range, as determined by a sweep increment switch. In the SEARCH & TRACK position, the instrument will scan as in the SWEEP position until it finds a signal, whereupon it will lock onto the signal and track it as in the TRACK POSITION. If the signal disappears, the analyzer will continue to scan automatically until the original signal or a new one appears. Since the sweep time, sweep increment, averaging time, and bandwidth are interdependent, a red light will appear if the various switches are set to a combination which would lead to erroneous results. With the MODE switch in the EXT position, the instrument may be tuned by an external DC voltage.

Two or more Model 304T(TDs) may be connected together without modification to form a multi-channel, phase locked, master-slave analyzer system suitable for mechanical impedance and transfer function analysis.*

A multiplicity of outputs greatly increases the versatility of the Model 304T(TD). When used with an X-Y plotter it can automatically make an amplitude vs. frequency or amplitude-phase plot of the characteristics of an electronic or electromechanical system. When used with an oscilloscope, X-Y plotter, or strip-chart recorder it becomes a

spectrum analyzer whose center frequency, sweep width and resolution can all be varied over wide limits. Averaging time, bandwidth, and sweep speed can be selected for optimum results in random signal analysis.

*Accessory Model 1304 Slave Filter and Phasemeter. In multi-channel installations where the slaved units never need to work independently, we recommend the Model 1304 which has a built-in phase meter but no tuning or sweep features. Mechanical impedance and transfer function analysis is simplified and at a considerable saving in cost.

B. SPECIFICATIONS

FREQUENCY RANGE:	1.0 Hz to 5.0 KHz
ACCURACY:	+ 0.5% or 1 Hz (TD-0.01%)
DIAL:	Linear, 1.0 Hz per division
SELECTIVITY:	Three pass bands, 1 Hz, 10 Hz, and 100 Hz at 3 db down, selectable by front panel switch. Maximally flat (Butterworth approximation) with 24 db roll-off. Also broadband to 6.5 KHz.
SENSITIVITY RANGE:	30 μV to 300 volts full scale in 10 db steps. Also variable gain control of 20 db.
DYNAMIC RANGE:	>70 db for Fourier analysis, > 40 db for random signal analysis.
ACCURACY:	± 5%
INPUT IMPEDANCE:	1 Megohm
AVERAGING TIMES:	Approximately < 0.1, 1, 10 and 100 seconds, switch selectable.
TUNING MODES:	(Manual, (Manual plus AFC, Track, Sweep, Search and (Track, external.
AFC:	Will hold over approximately 4 bandwidths
TRACK INCREMENT:	50, 100, 500, 1000, or 5000 Hz from dial setting, switch selectable.
THRESHOLD:	Adjustable from approximately 5% to 50% of full scale.
SWEEP TIME:	5, 50, 500, or 5000 seconds, switch selectable.
INCREMENT:	50, 100, 500, 1000 or 5000 Hz switch selectable

MODES: Single or repetitive, with reset.

OUTPUTS ON FRONT PANEL

SWEEP ANALOG:	0 to +5 volts for any sweep increment.
AMPLITUDE ANALOG:	0 to 10 volts proportional to meter deflection.
BFO:	Sine wave output at the frequency to which the instrument is tuned. Variable to approximately 1 volt RMS into 600 ohms.
RESTORED FREQUENCY:	A replica of the input signal filtered in accordance with tuning and bandwidth.
	Note: Either BFO or Restored output is selected by a switch. Simultaneous BFO and RESTORED available as an option.

AVAILABLE AT REAR CONNECTOR:
Same outputs as on front panel, plus:

FREQUENCY ANALOG:	DC output proportional to the frequency to which the instrument is tuned +1.0mv/Hz, +5V max.
EXTERNAL SWEEP INPUT:	± 5V max. for ± sweep increment from dial setting.
PHASE OUTPUTS:	In-phase and quadrature components, each equal to at least 1 volt peak-to-peak for full scale deflection.
MASTER-SLAVE CONNECTIONS:	10 KHz crystal controlled, 10 to 15 KHz variable.
POWER INPUT:	117/234 VAC, 50 to 400 Hz, 15 Watts.
DIMENSIONS:	11 1/6" x 15" x 11 1/4".
WEIGHT:	26 lbs.

A thorough understanding of an instrument and its principle of operation greatly enhances its usefulness. The Model 304T(TD) Wave and Spectrum Analyzer is a precision instrument capable of performing accurate signal analysis. For the most effective application of this equipment we strongly recommend that the prospective operator read Section 3, the Theory of Operation, before using the instrument.

A study of both the block diagram and the following description, along with the panel markings, will help to familiarize the operator with the functions of the various panel controls.

A. DESCRIPTION OF CONTROLS, INPUTS AND OUTPUTS

1. MANUAL TUNING - The COARSE, FINE and ZERO controls, by means of electro-mechanical linkage, can each change the frequency of a voltage controlled oscillator (VCO) thereby tuning the instrument. The controls differ in both range and resolution, but are alike in that each control precisely converts angular motion to a change in frequency of the VCO.

2. AUTOMATIC TUNING MODES - In addition to manual control of the VCO, provision has been made to electronically tune it in any of several modes as selected by the MODE switch.

   a. In the AFC mode, the instrument will follow a signal which moves no more than four instrument bandwidths.

   b. In the TRACK mode, the instrument will track a moving signal over selectable increments of the instrument tuning range. Increment width is selected by means of the RANGE control. A rear access control (TRACKING THRESHOLD ADJUST) is provided to permit amplitude discrimination of the tracked signal.

   c. In the SWEEP mode, the operator may scan in its entirety or incrementally, the spectrum from 1 Hz to 5 KHz. The increment width again is selectable by means of the RANGE control. The scan time per range increment is selectable by means of the TIME control (5 to 5000 seconds).

   d. The SEARCH AND TRACK mode is a combination of the Sweep mode and the Track mode. One may electronically scan the spectrum or portions thereof as in the

Sweep mode. When a signal of given amplitude, as determined by the TRACKING THRESHOLD ADJUST is found, the instrument will automatically switch to the Track mode and track the signal. If the signal moves beyond the range increment or drops below the pre-set threshold, the instrument will revert to the scanning mode until it once again finds a signal.

e. Provision has been made for the operator to externally program the electronically tuned VCO by means of a connector on the rear apron of the instrument. This function is accomplished with the MODE switch in the EXT position.

The RESET/SINGLE/AUTO switch provides for single or repetitive scanning in the SWEEP or SEARCH and TRACK modes of operation.

The RESET is a defeat position for the AFC and TRACK modes as well as for the SWEEP or SEARCH AND TRACK modes. An analog voltage is available at the SWEEP ANALOG jack for operating oscilloscopes, recorders, etc.

3. MASTER SLAVE mode

This mode of operation is controlled by a switch at the rear of the Model 304T (TD). For normal or master operation, the MASTER-SLAVE switches are left in the MASTER position. The switches are thrown to the SLAVE position if one wishes to drive one or more 304T(TDs) as phase locked slave units, subordinate to a 304T(TD) designated as MASTER. For instance, if one wishes to make simultaneous electronic measurements of two or more points related in phase and amplitude by some complex transfer function, one may use two or more 304T(TD) Wave Analyzers as slaved units, phase locked to and driven by the master unit.

4. SENSITIVITY

The METER MULTIPLIER, VARIABLE GAIN and MILLIVOLTS FULL SCALE controls set the instrument's sensitivity and provide for a combined range of 130 db. The METER MULTIPLIER and VARIABLE GAIN controls are associated with the input circuits and serve to adjust the input signal level to the correct value for analysis. The MILLIVOLTS FULL SCALE switch is in essence a range switch for the voltmeter. The sensitivity of the Analyzer is increased in 10 db increments as this control is rotated counter-clockwise. For absolute amplitude measurements, the 20 db VARIABLE GAIN control should be rotated clockwise to the CALIBRATED detent. The meter will then read directly in millivolts x the METER MULTIPLIER.

5. SELECTIVITY

The overall passband of the system is controlled by the BANDWIDTH switch and may be set to 1, 10 or 100 Hz, or 6.5 KHz. In the 6.5 KHz position the instrument functions as a broadband AC averaging voltmeter. This position is used to determine whether or not a signal exists in the input which might tend to overload the instrument. The instrument full scale reading in this case is equal to the METER MULTIPLIER setting x 1000 mv.

6. METERING

The METER T.C. switch provides for the selection of meter averaging times. The operator will find it helpful in that the averaging time can be changed by the same ratio as the system bandwidth, namely, 10:1. The selectable averaging time is of particular usefulness in the measurement of noisy signals.

The METER ZERO controls provide a means of periodically balancing critically matched circuits which are subject to change with time and temperature. Circuit unbalance is indicated by a finite meyer reading with no signal applied and should be "zeroed out" for correct operation.

For recording purposes, the METER ANALOG voltage is made available both at a jack on the front panel and at a connector at the rear of the instrument.

7. BFO AND RESTORED

Either of these signals may be selected and its amplitude adjusted by the two controls provided. The BFO is a sine wave equal to the frequency to which the instrument is tuned, whereas the RESTORED signal is equal to the input signal after it has been passed through a 1, 10, or 100 Hz filter and therefore is only available when the instrument is tuned to an input signal.

B. INITIAL OPERATION

1. Connect the instrument to a suitable source of power.

   a. AC Operation. Refer to plate located near the power cord for the voltage and frequency for which the instrument is wired. (See Section 4)

2. Allow at lease 10 minutes for the instrument to stabilize before making any adjustments.

3. Calibrate the dial for frequency accuracy as follows:

   a. Set panel controls as indicated below:

(1) MILLIVOLTS FULL SCALE	30
(2) METER TC	< .1
(3) VARIABLE GAIN	CALIBRATED
(4) METER MULTIPLIER	XI
(5) BANDWIDTH	100
(6) FREQUENCY READOUT	000
(7) "MODE" SWITCH	OFF
(8) MASTER-SLAVE SWITCHES	MASTER

   b. Tune the FREQUENCY ZERO control for a maximum meter reading (Model 304T only).

   c. Set BANDWIDTH to 10 Hz and again peak meter reading.

   d. Switch to a bandwidth of 1 Hz and very slowly adjust the FREQUENCY ZERO for a maximum meter reading. A low frequency beat will occur if the meter zero has not been adjusted.(Model 304T only)

4. Zero the meter as follows:

   a. Set the frequency such that the instrument is tuned neither to an incoming signal nor the 000 carrier.

   b. Turn the MILLIVOLTS switch counterclockwise to progressively more sensitive ranges. As the sensitivity of the instrument is increased, a residual voltage may be discernible. Alternately adjust the METER ZERO controls for a minimum meter reading, adjusting for the best possible null on the most sensitive range. (This should be less than 2% of full scale).

      Note: The instrument is now ready for operation. However, for best performance the above procedure should be repeated periodically.

C. MANUAL OPERATION

Since the exact procedure for operating the controls depends in large part on the nature of the test to be performed, consider the following example of manual operation.

A one volt, 1 KHz signal is to be analyzed for harmonic distortion.

1. Set BANDWIDTH switch to 6.5 KHz

2. Set MILLIVOLT FULL SCALE switch to 1000

3. Set METER MULTIPLIER switch to x 1

4. Turn the VARIABLE GAIN control clockwise to detented CALIBRATED position.

5. Select a METER T.C. of $<$ .1 sec.

6. Connect the signal to the INPUT
(The black post is chassis ground)

The meter should read approximately full scale. If it does not, the VARIABLE GAIN control may be adjusted such that it does. If the meter reads over full scale, it indicates that there is a signal present at the INPUT, lying within the 6.5 KHz range, which will overload the instrument front end. If the range of the VARIABLE GAIN control is not sufficient to bring the meter reading to full scale, the METER MULTIPLIER should be switched to the x 10 or x 100 position in order to do so.

7. Set the BANDWIDTH to 100 Hz

8. Tune the FREQUENCY dial to the 1 KHz signal

9. Adjust MILLIVOLTS FULL SCALE switch to obtain a full scale meter reading.

If there had been only the 1 Volt 10 KHz signal present at the INPUT the meter would have read full scale in the 6.5 KHz BANDWIDTH switch position with a METER MULTIPLIER setting of x 1 and a MILLIVOLTS FULL SCALE setting of 1000. The presence of a signal of greater than 1 Volt amplitude at some frequency other than 1 KHz necessitates decreasing the input sensitivity to prevent overloading, hence one must increase in proportion the metering circuit sensitivity when examining the 1 KHz signal with the BANDWIDTH switch in one of the more selective settings.

Now that both the amplitude and frequency of the fundamental signal are known, measure the second harmonic content by setting the dial to twice the fundamental frequency (approximately 2 KHz). Rotate the MILLIVOLTS FULL SCALE switch counterclockwise until the meter reads up scale. This measure of the second harmonic may now be related to the fundamental signal by expressing its magnitude in percentage of, or decibels below one Volt. Similarly by successively tuning to 3, 4 and 5 KHz, the magnitude of the third, fourth and fifth harmonics of the fundamental may be measured.

D. AUTOMATIC MODES

1. AFC

a. Adjust instrument as in steps 1 - 9 of Manual operation.

b. Set the SINGLE/AUTO/RESET switch to RESET position (effective AFC defeat).

c. Set MODE switch to AFC position.

d. When SINGLE/AUTO/RESET switch is switched to either SINGLE or AUTO, the AFC becomes effective.

The AFC will hold for approximately 4 times the BANDWIDTH switch setting.

2. TRACK

a. With MODE switch in OFF position tune instrument to a desired signal component as in Sect. C-MANUAL OPERATION.

b. Set RESET/SINGLE/AUTO switch to RESET position.

c. By means of the RANGE switch, select the spectrum increment over which it is desired to track the signal.

d. Choose the bandwidth and meter time constant as required (see note).

e. Set the TIME switch to the shortest time which does not light the red indicator lamp. (see note)

f. Switch the RESET/SINGLE/AUTO switch to AUTO. The instrument will now track the signal over the range $\pm$ (Δf) from the manually set dial frequency (f).

g. Determine over what range of amplitude variation the 304T (TD) is to remain locked onto the signal.

h. With signal initially at full scale meter deflection, attenuate the signal input by means of the METER MULTIPLIER and/or VARIABLE GAIN controls until the meter deflection indicates the amplitude point at which it is desired that the instrument cease tracking the signal.

3. SWEEP

a. Set FREQUENCY dial to the frequency at which the sweep is to start.

b. Select the SWEEP width; 50, 100, 500, 1000 or 5000 Hz.

c. Set the SWEEP time (See Note)(5, 50, 500, 5000 sec.)

d. Select the bandwidth and metering time constant as required. (See Note).

e. To initiate the sweep, operate the RESET/SINGLE/AUTO switch first to RESET then back to either the AUTO or SINGLE positions.

(1) AUTO - Instrument will continuously scan the selected frequency range.

(2) SINGLE - Instrument will make one scan, stopping at the top of the selected frequency range. The unit will then maintain this tuning until manually detuned or reset.

4. SEARCH AND TRACK

a. The instrument is adjusted as in the Sweep mode of operation with the exception that when it finds a signal, it will switch to the Track mode of operation and hence the TRACKING THRESHOLD ADJUST must be set.

Note that as in the Sweep mode, the instrument scans upward through a given range increment, whereas once a signal has been found, the instrument will track both + and - from dial setting by that same range increment.

5. EXTERNAL

In this mode of operation a $\pm$ 5V control voltage applied to the EXTERNAL input at the rear connector of the instrument will electronically tune the instrument by the RANGE increment (Δ f), $\pm$ from the dial setting FREQUENCY (f).

Note: In the interest of providing maximum versatility, the bandwidth, sweep, and averaging time controls have not been interlocked such as to always provide maximum accuracy. The operator must therefore consider with care his choice of setting.

The field of waveform and spectrum analysis is both broad and complex. There are, however, several excellent texts and articles published on the subject and therefore no attempt will be made in this short manual to cover it thoroughly; Instead listed below are a number of basic formulae and notes intended merely to serve as a guide to the effective usage of the equipment.

1. Sweep or Track rate (Hz) $= \frac{\text{Sweep or Track RANGE } (\Delta f)}{\text{Sweep or Track TIME PER } (\Delta f)}$

$$\text{or } SR = \frac{W}{T}$$

2. The maximum SR, with regard to bandwidth, should not exceed the following formula:

$$SR_{(Max)} = \frac{(BW)^2}{(2)}$$

This refers to the analysis speed limitation imposed by the system bandwidth and can be violated only at the expense of accuracy.

3. The averaging time (METER T.C.) should be selected according to the accuracy requirements of the particular test. In the case of pure random noise, the statistical error (e) due to finite filter bandwidth and averaging time may be estimated by:

$$e = \sqrt{\frac{1}{8BW \times TC}}$$

where: e= Probable error
BW= Effective filter bandwidth
TC= Meter time constant

E. PHASE MEASUREMENTS

An extremely useful feature of the Model 304T(TD) is its capability of supplying analogs of both the real and imaginary portions of the input signal when the specimen under test is excited by the BFO. The significance of this is, of course, that if these two dc voltages are simultaneously plotted against one another, a polar diagram will result - from which the phase response characteristics of the specimen may be determined. The information can be displayed on either an oscilloscope or an X-Y recorder and the specimen may range from a simple network to a complex electro-mechanical system. Furthermore, the testing can be performed manually or automatically depending on the setting of the sweep controls.

1. ACCURACY

No attempt has been made to normalize the phase response of the basic model 304T (TD) itself, however, the system phase shift is quite linear with frequency and therefore it can be readily subtracted from the total. Another method more suitable for incremental phase measurements would be to make the desired plot using an X-Y recorder and calibrated paper, then on the same paper, plot the system phase shift. Mechanical normalization can result in accuracies of a fractional degree.

2. EXAMPLE

Consider measuring the phase response of a bandpass filter centered at 1 KHz and having a bandwidth of 100 Hz.

a. Calibrate the dial and zero the meter.

b. Connect the BFO to the filter input and connect the filter output to the input terminals of the Model 304T (TD).

c. Set the FREQUENCY dial to 1000 Hz and the BANDWIDTH to 100 Hz.

d. Adjust the BFO to the desired level, keeping it as high as is practical.

e. Adjust the input attenuators and meter sensitivity controls such that the meter reads up-scale.

f. With no signal input, establish the X and Y axes on the paper, adjust the recorder sensitivity (j and R each = approx. 1 V p-p for a full scale meter reading) and set the pen at the origin.

g. Connect the outputs of the Model 304 to the recorder inputs, j to X and R to Y. With the pen lifted make a dry run to check equipment connections, sensitivities, etc. The final test can then be made by scanning the spectrum of interest either manually or automatically.

A. THEORY OF OPERATION

The Model 304-T/TD is basically a dual conversion hetrodyne receiver having a 10 KHz first IF and a zero center frequency second IF.

The variable oscillator is a voltage controlled oscillator producing an output variable from 10 to 15 KHz. It is extremely stable and linear, and enables the instrument to be electronically swept over its whole range by an internal ramp in the SWEEP mode. In the AFC, TRACK, and SEARCH & TRACK modes a phase detector controls the variable oscillator enabling the instrument to track a moving signal.

Referring to the block diagram, the incoming signal goes through a step attenuator and source follower into a low pass filter which removes frequencies above 5 KHz. The signal is then mixed with the output of the 10 to 15 KHz variable oscillator. The difference frequency is passed through the 10 KHz first IF to a pair of second modulators. The two second modulators are driven 90° out of phase by a two-phase 10 KHz crystal oscillator. The difference frequencies are then passed through a pair of four-pole maximally flat active low pass filters with selectable cutoff frequencies of 0.5, 5, and 50 Hz. Since the center frequency of the second IF is zero (DC), and the difference signals can go plus and minus, the resultant bandwidths are 1, 10 and 100 Hz. The low frequency filtered signals from the two channels are then chopped at 10 KHz, again 90° out of phase, and recombined in a summing circuit. The summed signal is amplified and rectified and drives the meter and meter analog.

Phase information can be obtained from the DC outputs of the R and J channels. The R channel balanced modulator is driven from the same phase of the two-phase 10 KHz crystal oscillator as the BFO output modulator. Thus a signal from the BFO output of low enough frequency not to have phase shift introduced by the two low pass filters in the circuit will produce a DC output from the R channel, and none from the J channel, which has been chopped at 90° out of phase. If phase shift is introduced between the BFO output and the input to the first modulator, the R output will decrease and the J output increase until at 90° there will be no R output and maximum J output. In this way the Model 304-T/TD can separate the real from the imaginary parts of a voltage derived from a device driven by the BFO output.

The BFO output is a constant amplitude signal of exactly the frequency to which the instrument is tuned. It is obtained by mixing the 10 KHz fixed oscillator with the 10 - 15 KHz variable oscillator and taking the difference frequency. Unwanted higher frequency modulation products are removed by a low pass filter.

The RESTORED signal output is a filtered replica of the input signal exactly equal in frequency and proportional in amplitude. It is obtained by mixing the summed 10 KHz signal with the variable oscillator output and taking the difference frequency.

In the AFC and TRACKING modes a phase detector compares the phase difference between the second (Rø,Jø) and fourth (Rn,Jn) poles of both of the low pass filters and produces a DC voltage of proper amplitude and polarity to tune the variable oscillator so that the desired signal is in the center of the pass band. Control of the variable oscillator by the output of the phase detector is inhibited unless the signal is in excess of the threshold determined by a rear panel adjustment. Output from the phase detector is attenuated in accordance with the bandwidth, tracking range, and tracking speed in use.

B. CIRCUIT DESCRIPTION

1. +10 VOLT SUPPLIES, +5 VOLT SUPPLY, +160VOLT SUPPLY - SCHEMATIC T-6752

The -10 volt supply has as its reference CR108. The error signal between this reference and the midpoint of the voltage divider formed by R113 and R108, with its padding resistor R107, is amplified by IC101, which drives the pass transistor Q104. Q103 is a current generator to insure that the supply will start up. The +10 volt supply receives its reference voltage from the -10 volt supply through a voltage divider formed by R114 and R115. The error amplifier IC102 drives the pass transistor Q105. The +5 volt supply is regulated by a simple two-transistor amplifier Q101 and Q102, obtaining its reference from the +10 volt supply through the voltage divider R101 and R102. These supplies are all adjusted at the factory and should require no further calibration. The +160 volt supply is required only for the Model 304-TD to operate the gas discharge tubes in the digital readout.

2. LAMP CIRCUIT - SCHEMATIC T-6753

The green MODE lamp DS101 lights whenever the instrument is in any mode except manual tuning. The red SWEEP lamp DS102 lights when the bandwidth switch, the sweep speed switch, and the sweep increment switch are set to positions that would give misleading results if the instrument were used under these conditions.

3. INPUT, LOW PASS FILTER, PRE-AMPLIFIER, and FIRST MODULATOR - SCHEMATIC T-6754

The input step attenuator has an input impedance of 1 megohm and is followed by an FET source follower as an impedance converter. The source follower drives the low pass filter, which is followed by the variable gain control, which in turn drives the pre-amplifier IC101. The pre-amplifier drives the balanced modulator Q103 and Q104, a complementary pair, which are driven in phase by the push-pull complementary drivers Q105 and Q106. The balanced output from this modulator is fed to the transformer input of the 10 KHz first IF filter.

4. BANDPASS FILTER, STEP ATTENUATOR and IF AMPLIFIER - SCHEMATIC T-6755.

The output of the 10 KHz bandpass feeds amplifier IC101, which in turn feeds the MILLIVOLTS FULL SCALE step attenuator. The step attenuator in turn feeds the IF amplifier drivers IC102 and IC103, which drive the two second modulators.

5. FIXED OSCILLATOR and SECOND MODULATOR - SCHEMATIC C-6756

The 10 KHz fixed oscillator frequency is derived from a 40 KHz crystal oscillator IC101. The 40 KHz output is divided by four by IC102 and IC103. The circuitry is so arranged as to obtain two 10 KHz outputs precisely 90° out of phase. The 10 KHz quadrature signals are available at J102 and J103 to drive another Model 304T/TD or a Model 1304, as slave units. With S109 in the SLAVE position, the instrument may be driven as a slave analyzer from another Model 304T or TD. The quadrature signals drive complementary push-pull pairs Q105 - Q106, and Q107 - Q108, which in turn drive

the complementary pair quadrature balanced modulators Q101 - Q102, and Q103 - Q104. The outputs of the balanced modulators are fed to the two low pass filters through their appropriate bandwidth switches.

6. LOW PASS FILTERS AND AMPLIFIERS - SCHEMATIC C-6757

The R and J Channel filters and amplifiers are identical. Each of the filters consists of two two-pole RC active networks with capacitors selectable by the bandwidth switch. The first section has a gain of approximately 50. A balanced FET input stage, Q101, is used to minimize DC drift in the amplifier IC101. The second section is also a two-pole network, having a gain of slightly more than 1. The gains of the two amplifier sections are adjusted so that the overall response is that of a maximally flat or Butterworth filter. Separate outputs are taken from both the second (ø) and the fourth(N) poles of each filter. The phase difference between these points is later measured in the phase detector and used to control the variable oscillator in the AFC and TRACK modes. The gain in these channels is pre-set at the factory and should not be changed.

7. CHOPPER and PHASE DETECTOR - SCHEMATIC C-6758

The outputs obtained from both the second (Rø,Jø) and fourth (Rn,Jn) poles of both the R and J channels are chopped at 10 KHz in the quadrature choppers Q101-Q102, and Q103 - Q104. The outputs are summed and amplified in the selective amplifiers IC101 and IC102. The filtered outputs are squared in squaring amplifiers, IC103 and IC104, and the phase difference between the second (ø) and fourth (N) poles of both low pass channels are compared in phase detector IC105. The DC output of the phase detector is filtered and amplified in IC106, where a necessary DC offset is also introduced. The amplified DC output is then either passed or stopped by Q105, which is controlled by the threshold adjustment on the metering circuit board. The chopped, summed and filtered output from the fourth poles (Rn + Jn) of the R and J channels are passed on to the metering circuit through the millivolts switch S108 and bandwidth switch S104. In the 6500 Hz bandwidth position, the output from the pre-amplifier is fed directly to the metering circuit board, by-passing all intervening circuitry.

8. SWEEP GENERATOR - SCHEMATIC T-6759

The switching functions and resistor values in this schematic are somewhat complex and need not be explained in detail. The resistance values have been optimized to give proper tracking, sweep, and sweep length capabilities. The sweep generator itself consists of Q101, IC101A, and Q103, which form a Miller Integrator which charges C101 linearly with time. When the voltage across C101 reaches a value equal to a reference voltage set by R129, IC101B is tripped, discharging C101 through Q102, provided that the sweep selector switch is set in the AUTOMATIC mode. If the switch is in the SINGLE mode, the sweep will merely rise to its maximum value and remain there until a RESET or AUTOMATIC mode has been set. In the RESET mode C101 will remain permanently discharged by Q102.

9. IMPEDANCE CONVERTER - SCHEMATIC T-6760

Here again the resistance networks associated with the mode, sweep range, and bandwidth switches provide optimum performance in the sweeping and tracking operations of the instrument. IC-102A is an impedance converter which provides a variable reference voltage to IC-102B. IC-102B also receives a differential reference voltage from the frequency control potentiometer on the front panel. Q101 provides a low output impedance to drive the frequency analog and to control the frequency of the variable oscillator.

10. VARIABLE OSCILLATOR and DIVIDE BY 40 CIRCUIT SCHEMATIC T-6761

The variable oscillator is basically an extremely stable, free-running multi-vibrator, Q101 and Q108. Its frequency is controlled from the impedance converter by linearly varying the current through Q102 and Q107. This current varies the discharge time of the timing capacitors C103 and C104. Q103 and Q106 function as non-linear collector loads to keep the dissipation in the circuitry at a minimum. Since multivibrators are often hard to start, there is a self-starting circuit consisting of Q104 and Q105. The output of the multi-vibrator is isolated and amplified by Q109 to provide maximum stability. Since the Model 304TD presents new frequency data four times per second, the oscillator operates at a frequency of 400 to

600 KHz to run the digital circuitry. The output of the oscillator is divided by 40 by IC101 and IC102 to provide the 10 to 15 KHz variable oscillator output. This output is also available at J105 to run other slave analyzers.

11. METER CIRCUIT - SCHEMATIC T-6762

The meter amplifier consists of isolation amplifier IC101 and rectifier amplifier IC102. The rectified output drives the threshold detector IC103, which controls the AFC and TRACKING modes. The rectified output also feeds the meter time constant circuit, which in turn feeds the impedance converter Q102 and the DC amplifier IC104. The output of IC104 drives the meter and the meter analog, which is clamped to ground by Q103 during retrace of the sweep, or when the switch is in the RESET position.

12. BFO AND RESTORED - SCHEMATIC T-6763

The output of the variable oscillator drives the complementary pair Q101 and Q102, which drive the balanced modulator Q103 and Q104. The other input to the modulator comes from the fixed oscillator for BFO output or the meter circuit for RESTORED output. The difference frequency is fed through two active low pass filters which remove the unwanted modulation products. A variable output attenuator is placed between the two sections.

A. GENERAL

The components and transistors in the Model 304-TD are conservatively rated and should provide long and trouble free service. If, however, the instrument has been damaged and recalibration or alignment is required, the following instructions should be followed explicitly, or the instrument returned to the factory. Instructions are given on the Warranty page for the procedure to be followed, should it be necessary to return the instrument for any reason.

Although the Model 304-TD is a complex instrument, trouble shooting can readily be done in sections as indicated in the Block Diagram.

DO NOT change any adjustment without a thorough knowledge of the circuit and the functions of the adjustment.

Standard transistor servicing care should be used throughout. Transistors can be easily damaged with large transient voltages. Therefore, take great care not to short any terminals when making measurements on the printed circuit boards.

In soldering to the printed circuit boards, have the iron only hot enough to make a rapid clean solder joint. DO NOT apply any force that would tend to push the copper away from the board.

B. REMOVAL FROM CASE

1. Remove the four screws from the rear of the case.

2. Slide the instrument gently out of the front of the case.

C. CHANGING INPUT VOLTAGE

This instrument has been designed to operate from a 117V AC or a 234V AC power source. The switch on the rear of the instrument near the power cord indicates the voltage and frequency at which the instrument should be operated.

Should it be desired to change the input voltage:

1. Change the transformer primary connections by moving the switch on the rear panel to the required voltage.

2. Change the fuse. For 117V AC operation the fuse should be 1/4 amp. slow blow; for 234V AC operation the fuse should be 1/8 amp. slow blow.

D. CALIBRATION

1. General

The Model 304-TD is a precision instrument, the accuracy of which depends in large part on critically balanced DC circuitry. The circuits in turn are designed to operate over a moderate temperature range. However, the instrument cannot cope with thermal shocks or transients which cause differential temperatures to occur between individual components. The closed-box environment provided by the Model 304-TD's case affords its circuits both thermal-transient and electrostatic shielding, thereby resulting in more stable operation. During calibration similar protection may be required in the interest of accuracy. It is also recommended that the new "extender boards" supplied with each instrument be used in the case of those adjustments which cannot be made without removing the circuit board. If a circuit board must be temporarily removed from its socket, or if the unit is momentarily turned off, be sure to allow the instrument time to restabilize before making further adjustments.

Following is an outline of the setup procedure. It is important that the adjustments be made in the prescribed order, inasmuch as some of them depend upon completion of the previous ones.

CAUTION

Included in this procedure are a number of adjustments which require the actual selection and installation of components. These particular adjustments are intended to be made ONLY on new assemblies or those which have received catastrophic damage necessitating a major overhaul. These components are denoted on the schematic drawings as "factory adjustments" (f.a.) and are NOT to be considered as routine adjustments.

Those adjustable controls not covered in the "Calibration Procedure" should NOT be adjusted. These are set at the factory during initial calibration and will not require further adjustment.

2. Adjustment Procedure Outline

a. Frequency Determinants

(1) Power Supplies
(2) Variable Oscillator and Impedance Converter
(3) Fixed Oscillator
(4) Sweep Circuits

b. Signal Channel

(1) Meter Zero Adjustments
(2) R/J Channel Balance
(3) Calibrate Gain Circuit
(4) Check Systems Gain

3. Test Equipment Required

a. VOM- Avometer or equivalent 20,000 Ohm/Volt
b. D.C.Voltmeter- 0.1% Accuracy
c. Oscillator - 10 Hz to 100 KHz 1 Volt out
d. VTVM - HP 400D or equivalent
e. Oscilloscope - Tektronix 503 or equivalent
f. Oscilloscope - 50 MHZ response with low-capacitance probe
g. Frequency Counter - Range 500 KHz accuracy 0.1%
h. Decade Attenuator - GR 1450 or equivalent

4. Initial Setting of Controls

Meter Zero Controls	Mid Range
Meter T.C.	.1
Millivolts Full Scale	1000
Bandwidth	100 Hz
Frequency Readout	0000.0
Fine Control	Mid Range
Meter Multiplier	X1
Variable Control	"Calibrated"
"Mode" Switch	Off
Sweep Range	5000
Sweep Time	5 Seconds
Sweep Function	Reset
BFO-Restored	BFO
Variable Control	Fully Clockwise
Rear Panel Switches	Master/Slave to Master, both switches to left

5. Calibration of Frequency Control Circuits

NOTE: ALLOW INSTRUMENT TO WARM UP FOR 15 MINUTES BEFORE ATTEMPTING THE FOLLOWING PROCEDURES.

a. Power Supplies Assy #6710-Test Equipment Item b.

(1) Monitor the minus 10 volt line with D.C.Voltmeter connected between emitter of Q104 and ground. Should read minus 10 Volts ± 100 millivolts. If necessary select R107 for correct reading.

(2) Monitor the plus 10 Volt line between emitter of Q105 and ground. Should read plus 10 Volts ± 200 millivolts. The plus supply reference is obtained from the minus supply and needs no adjustment.

(3) Monitor the plus 5 Volts supply at the collector of Q102. If necessary adjust R101 for + 4.8 to + 5.0 Volts output.

(4) Check the plus 160 Volt supply with "No Load" condition. This voltage will be approximately 170 to 180 Volts at normal line voltage

b. Variable Oscillator Assy #6707 Test Equipment Items b and g.

Front Panel Controls as in"initial setting"

(1) Monitor the "Variable Oscillator" frequency with counter at test socket (BNC on rear panel). Frequency should be 10 KHz ± 10 Hz. If necessary adjust R106 for correct frequency. Should it be necessary to adjust R106, allow circuit time to regain thermal stability before rechecking.

(2) Monitor frequency analog at pin 7 of J101 (power supply schematic) with D.C. Voltmeter for zero Volts ± 1 millivolt.

(3) Turn tuning control to vary frequency analog to 5 Volts ± 50 millivolts. Adjust R115 to display 5000 Hz on frequency counter. If manual tuning has a coverage of less than 1/4, turn clockwise to the end stop, adjust R122 on the baseboard

to give the required range (R122 shown on Impedance converter schematic and located between Assy #6708 and #6709 on rear base-board.

c. Fixed Oscillator Assy #6714

(1) Monitor "Fixed Oscillator" frequency at test socket (BNC) on rear panel, with frequency counter. Frequency should be 10 KHZ ± 0.5 Hz. This is a crystal controlled oscillator and no adjustment is available. "R" channel output leads "J" channel output by 90 degrees.

d. SWEEP GENERATOR Assy #7359-Test Equipment Items b and g.

Front panel controls as "Initial Setting" except MODE switch to SWEEP position.

(1) Monitor SWEEP ANALOG with DC Voltmeter at front panel connector. DC voltage should be zero volts, ±1 millivolt. Set SWEEP function to SINGLE sweep and adjust R128 for plus 5 Volts, ±10 millivolts after completion of sweep (5 sec.)

e. IMPEDANCE CONVERTER Assy #7360

(1) Turn MODE switch to OFF. Monitor the "Frequency Analog" on pin 7 of J101 with DC Voltmeter. Set FINE frequency tuning control to midrange and the COARSE tuning control approximately 1/4 turn clockwise from lower end stop, until DC Voltmeter reads zero Volts, ±25 MV. Switch MODE switch to SWEEP and allow instrument to sweep to the end of a SINGLE sweep. Adjust R125 to give 5 Volts, ±10 millivolts output.

(2) Check sweep ranges for designated widths within ±5%.

(3) Check SWEEP TIME as designated, within ±20%. NOTE: Since the sweep circuit generates a very linear ramp voltage (0 to ± 5 Volts) the total ramp time may be extrapolated by measuring only a portion of the total sweep voltage, perhaps 1 or 2 Volts.

6. Calibration of the Signal Channel

Front panel controls as in "Initial Setting" except:

Tune the frequency readout to 1 KHz and set "Millivolts Full Scale" switch to 3.

a. Low Pass Filter Assy #6715

In order to obtain both the required range and resolution of the METER ZERO controls, it is necessary to have both coarse and fine adjustments for each channel.

(1) Adjust the front panel METER ZERO controls (R101 and R102) to mid range.

(2) Monitor "R" and "J" channel low pass outputs (on rear baseboard) with D.V.M. or oscilloscope. Adjust R130 on each channel for minimum indicated output. Adjust front panel METER ZERO controls for final balance.

b. Phase Detector Assy #6716 Test Equipment Items c, d, and e.

Front panel controls as in "Initial Setting".

(1). Connect the oscilloscope to "Carrier" test point (on rear baseboard). With no input applied, null carrier output by adjusting (METER ZERO" controls on the front panel.

(2) Apply a 1 KHz signal of 1 Volt amplitude to the input of the Model 304-TD and tune instrument to the signal.

(3) Adjust R125 (lower pot on rear baseboard between Assy's 6715 and 6716) for minimum ripple. Should be less than 10%.

c. Tracking Adjustment - Set front panel controls as follows:

BANDWIDTH	100
MODE SWITCH	SEARCH AND TRACK
SWEEP TIME	5 SECONDS
SWEEP WIDTH	5000 Hz
SWEEP FUNCTION	RESET

(1) Connect "R channel low pass output (test point on top of rear baseboard) to the oscilloscope horizontal input (D.C. coupling). Connect the "J" channel low pass output (top of rear baseboard) to the oscilloscope vertical input (D.C. coupling). Adjust "X" and "Y" sensitivities to 0.2 millivolts/cm. Apply a 1 KHz signal, 1 Volt amplitude to the Model 304 TD input and tune the instrument to obtain a slowly rotating circular lissajou pattern.

(2) Change sweep function to "SINGLE" or "AUTO". Adjust R127 for phase lock on signal. (R127 shown on Chopper and Phase Detector schematic).

NOTE: Although the instrument is not intended to be a phase lock system, careful adjustment of METER ZEROs, balance and phase detector may enable phase locking in the tracking modes.

(3) Change sweep function to "RESET" and adjust manual tuning to a frequency just greater than one bandwidth above zero frequency. Apply a signal to the 304 TD input and set the sweep function to "AUTO".

The instrument will now start to search upwards in frequency and lock onto a signal of sufficient amplitude whose frequency is within the programed search range.

(4) Reduce the input signal amplitude and adjust the "TRACKING THRESHOLD" (on rear panel) to stop tracking the signal at 20% of full scale.

d. System Gain Calibration

Front panel controls as in "Initial Setting"

(1) Calibrate the gain of the overall system by applying a 1 KHz signal of an exact 1 Volt amplitude to the input. Tune the frequency to 1 KHz. Adjust "CAL GAIN" control on the rear panel for full scale reading on the front panel meter

(2) Switch "BANDWIDTH" to 6500 Hz and adjust R133,(pot is located on the baseboard near the pre-amp section)for full scale meter reading. (R133 is shown on the Chopper and Phase Detector schematic).

(3) Check "BFO" and "RESTORED" outputs at the front panel connector, no adjustment available.

SEMICONDUCTOR LEGEND

Changes and improvements in the semiconductor products available for commercial use necessitate type changes from time to time. To eliminate confusion and costly paperwork, many of these changes will be covered in the following legend. The purpose of this legend is to acknowledge the fact that the type number on a semiconductor found in a piece of equipment will not necessarily correspond with the type number given on the schematic diagram.

The legend is not intended to be an interchangeability list although in many cases good quality components* within a given category may be substituted with acceptable results. Normally, replacements should be made using components having the same type number as the component being replaced.

Those components bearing an asterisk on the schematic diagram are factory selected components and should be obtained from Quan-Tech.

*It should be noted that the incoming inspection procedure followed at Quan-Tech includes noise screening on most semiconductors.

TYPE NO. ON SCHEMATIC	TYPE NO. IN EQUIPMENT
1N482A	1N648, 1N3604, 1N3605
1N703	1N748, 1N749
1N709	1N753
1N2859	1N3253, 1N3254
1N2862	1N3254
1N3253	75A4, 1N3254
1N3254	75A4
1N3604	1N3605, 1N4151, 1N482A, 1N648
1N3605	1N3604, 1N4151, 1N482A, 1N648
MPD400	MPD401, 1N5179
TIS73	TIS74, TIS75, 2N4392
TIS74	TIS75, 2N4392
TIS75	TIS74, 2N4392
TI480	2N1613, 2N3566, 2N3643 A322, 2N929
TI494	2N1613, 2N3566, 2N3643, A322, 2N929
UC240	2N4869, 2N3819
2N270	2N3644, 2N3250, 2N3251
2N396A	2N414, 4JX1G759, 4JX1D653, 2N1305, 2N3644, 2N3250, 2N3251
2N414	2N396A, 4JX1G759, 4JX1D653, 2N1305, 2N3644, 2N3250, 2N3251

TYPE NO. ON SCHEMATIC	TYPE NO. IN EQUIPMENT
2N929	A322, A324, A642, 220N2, 2N930, 2N3566, 2N3643, 2N2219
2N1304	2N929, 2N930, 2N1306, 2N3566, 2N3643, A322
2N1306	2N929, 2N930, 2N1304, 2N3566, 2N3643, A322
2N1515	2N3644, 2N3250, 2N3251
2N1613	2N929, 2N930, 2N3566, 2N3643, A322, 2N2219
2N2219	D16C33, 220N2, A322, A324, A642, 2N929, 2N930, 2N3566, 2N3643
2N2603	2N3250, 2N3251, 2N3644
2N3250	2N3251, 2N3644
2N3251	2N3250, 2N3644
2N3566	2N3643, A322, 2N929, 2N2219
2N3643	2N3566, 2N2219, A322, 2N929
2N3644	2N3250, 2N3251, 2N3762
2N3762	2N3250, 2N3251, 2N3644
2N3819	TIS73, TIS74, TIS75, TIS58, TIS59, 2N4869, UC240
2N4392	TIS74, TIS75, 2N3819
2N4869	2N3819, UC240

SCHEMATIC LEGEND

k – 1000

– Screw Driver Adjustment

– Front Panel Control

* – Factory Select

Unless Otherwise Specified:

All Resistances in Ohms

All Capacitances in Microfarads

4/17/73

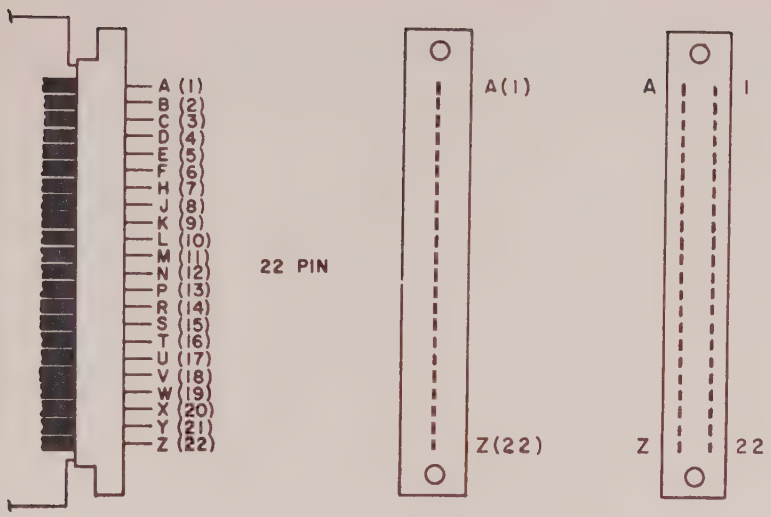


FIG. 1 PRINTED CIRCUIT BOARD LUG IDENTIFICATION

Fig. 1 illustrates the identification and orientation of a printed circuit board and connector utilizing 22 pins.

When a printed circuit board of a lesser number of pins is called for, the same designating sequence shall apply.

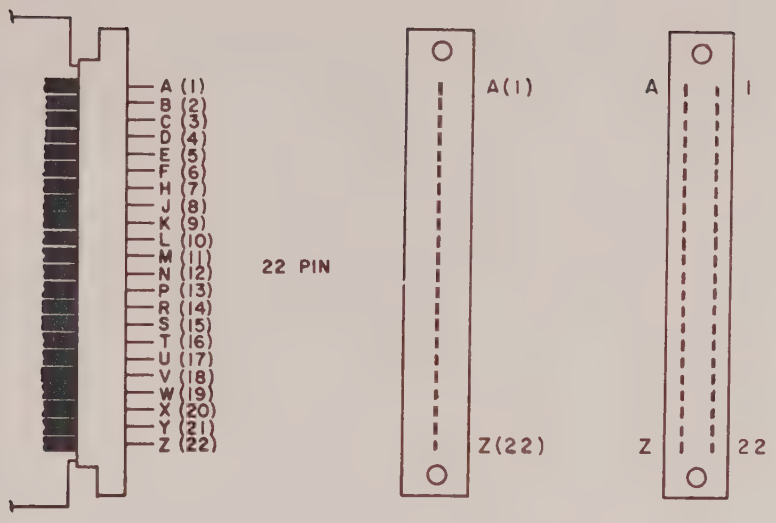
When a single sided copper P.C. Board is used, its pin identification shall be as shown in Fig. 1, and its schematic references shall be A(1), B(2), C(3) etc. The copper side faces the observer when viewed as shown at the left.

When using a double sided copper P.C. Board, its pin orientation shall be as shown in Fig. 1 and its schematic references shall be as follows:

a. (A), (B), (C) etc. signifies that electrical connections are made to lettered side of P.C. Board (A side).

b. (1), (2), (3) etc. signifies that electrical connections are made to numbered side of P.C. Board (1 side).

c. A(1), B(2), C(3) etc. signifies that electrical connections are made to both sides of P.C. Board simultaneously, i.e., A and 1 are schematically connected.



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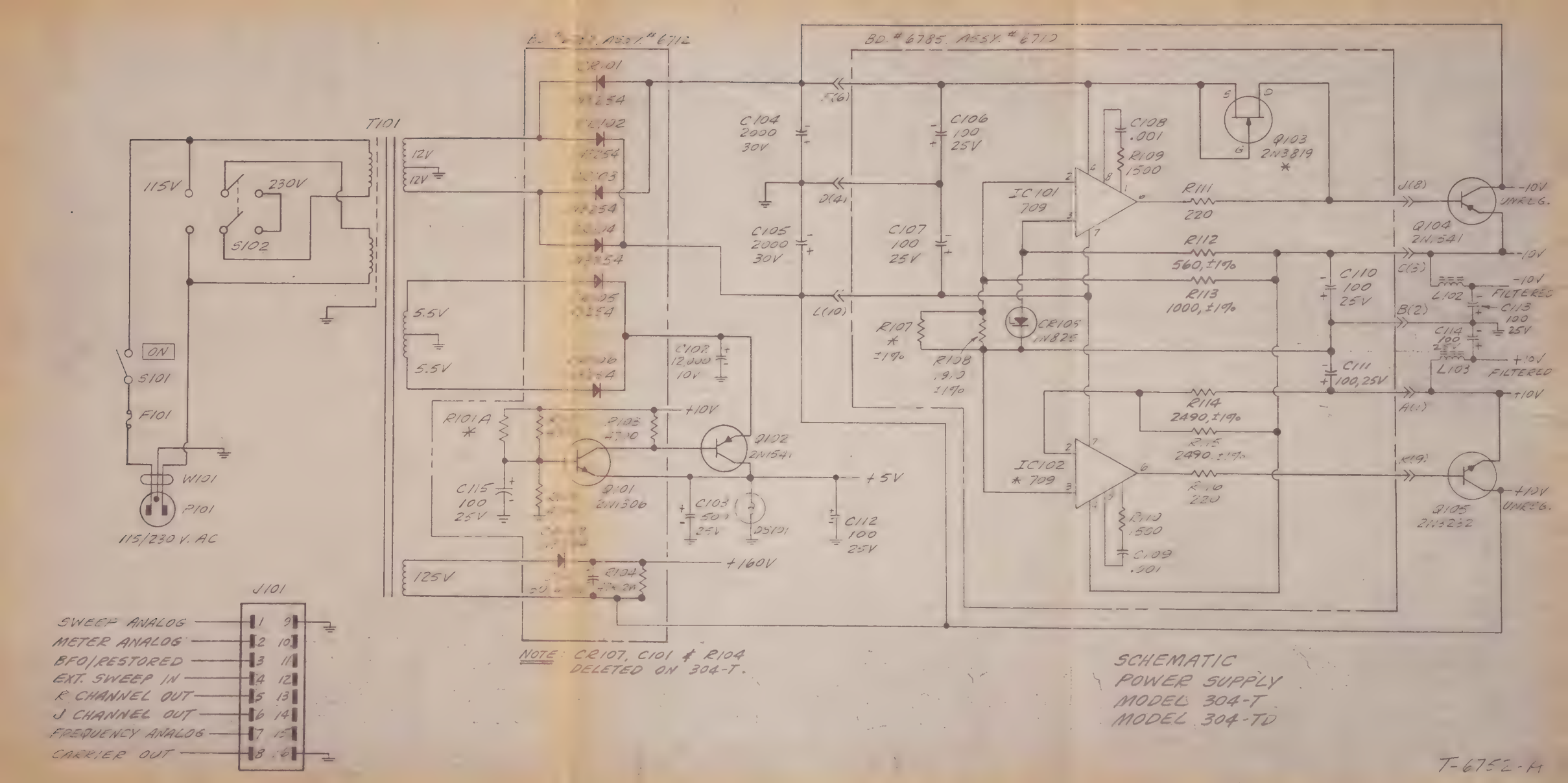


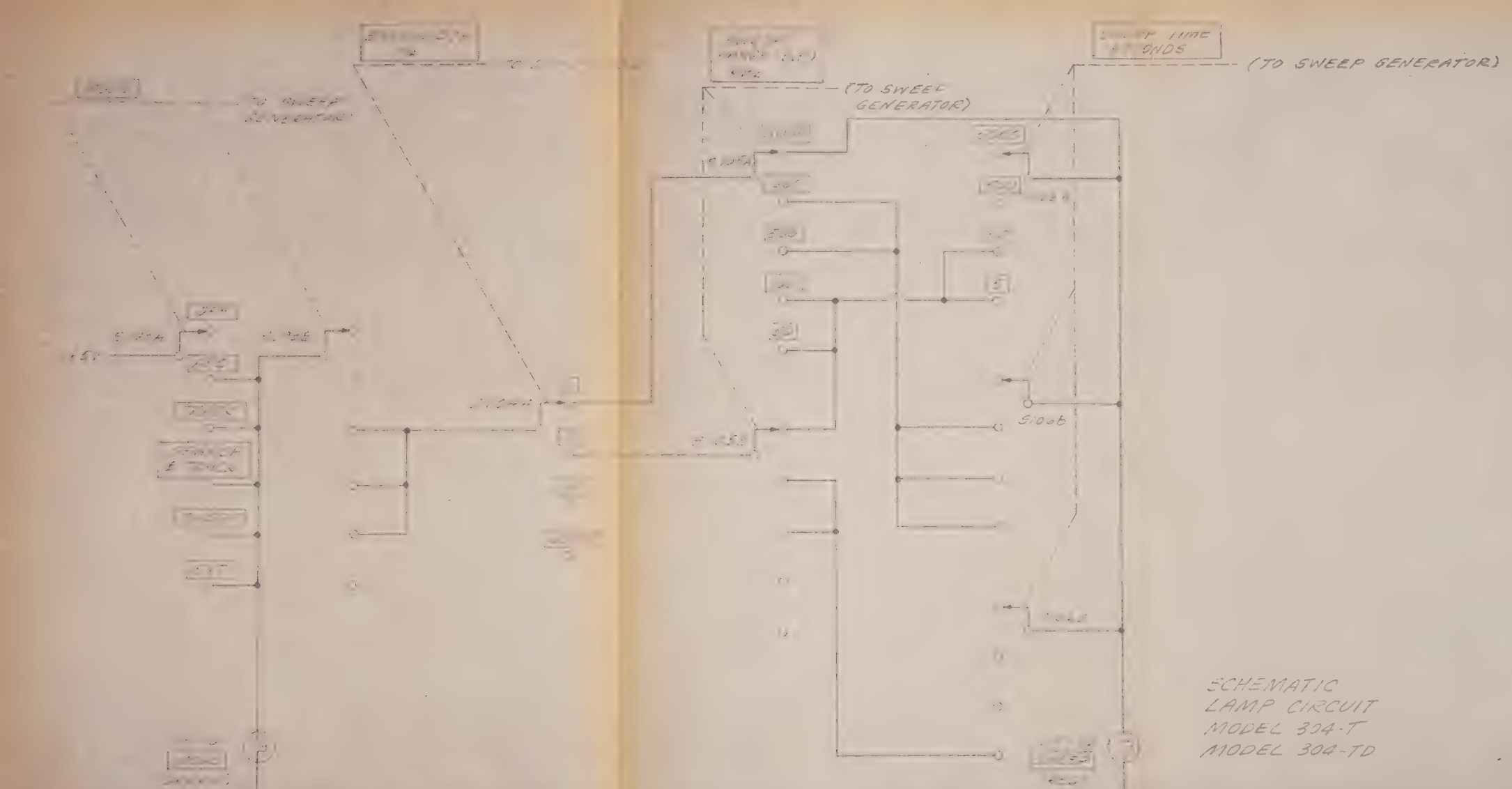
J101

SWEEP ANALOG	1	9
METER ANALOG	2	10
BFO/RESTORED	3	11
EXT. SWEEP IN	4	12
R CHANNEL OUT	5	13
J CHANNEL OUT	6	14
FREQUENCY ANALOG	7	15
CARRIER OUT	8	16

NOTE: CR107, C101 & R104 DELETED ON 304-T.

SCHEMATIC
POWER SUPPLY
MODEL 304-T
MODEL 304-TD

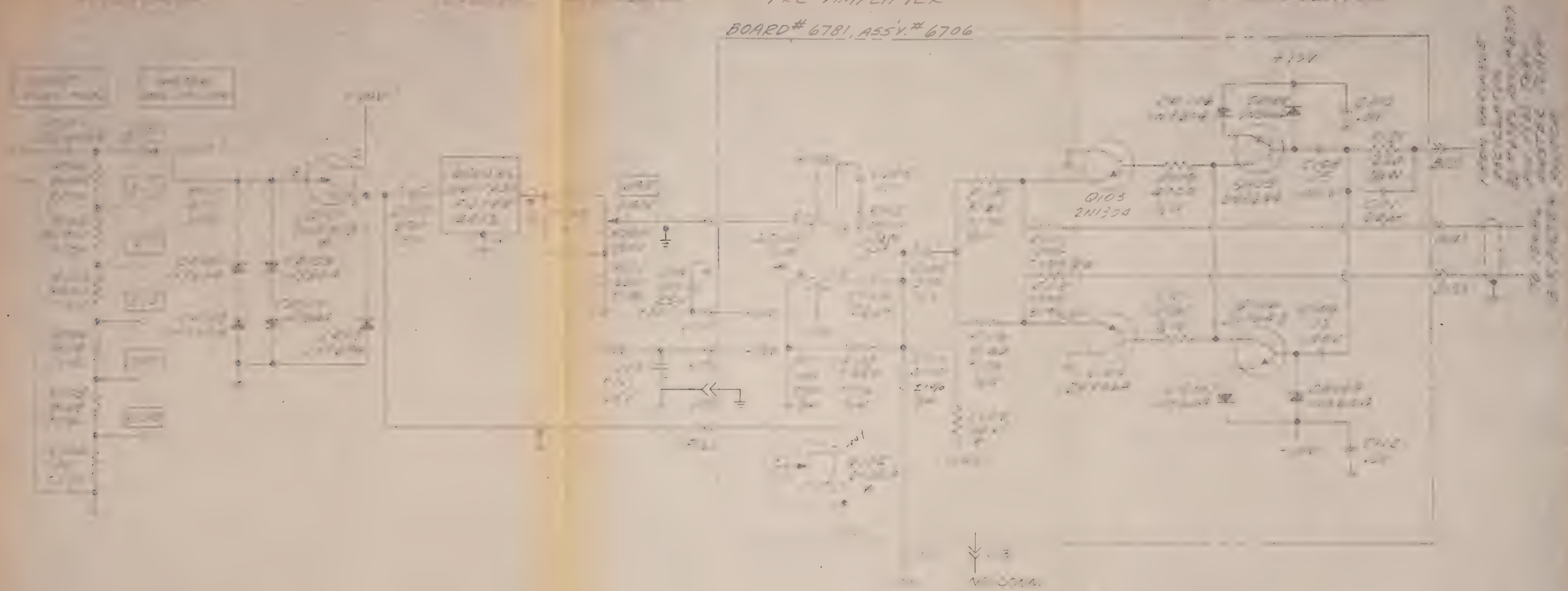
T-6752-H



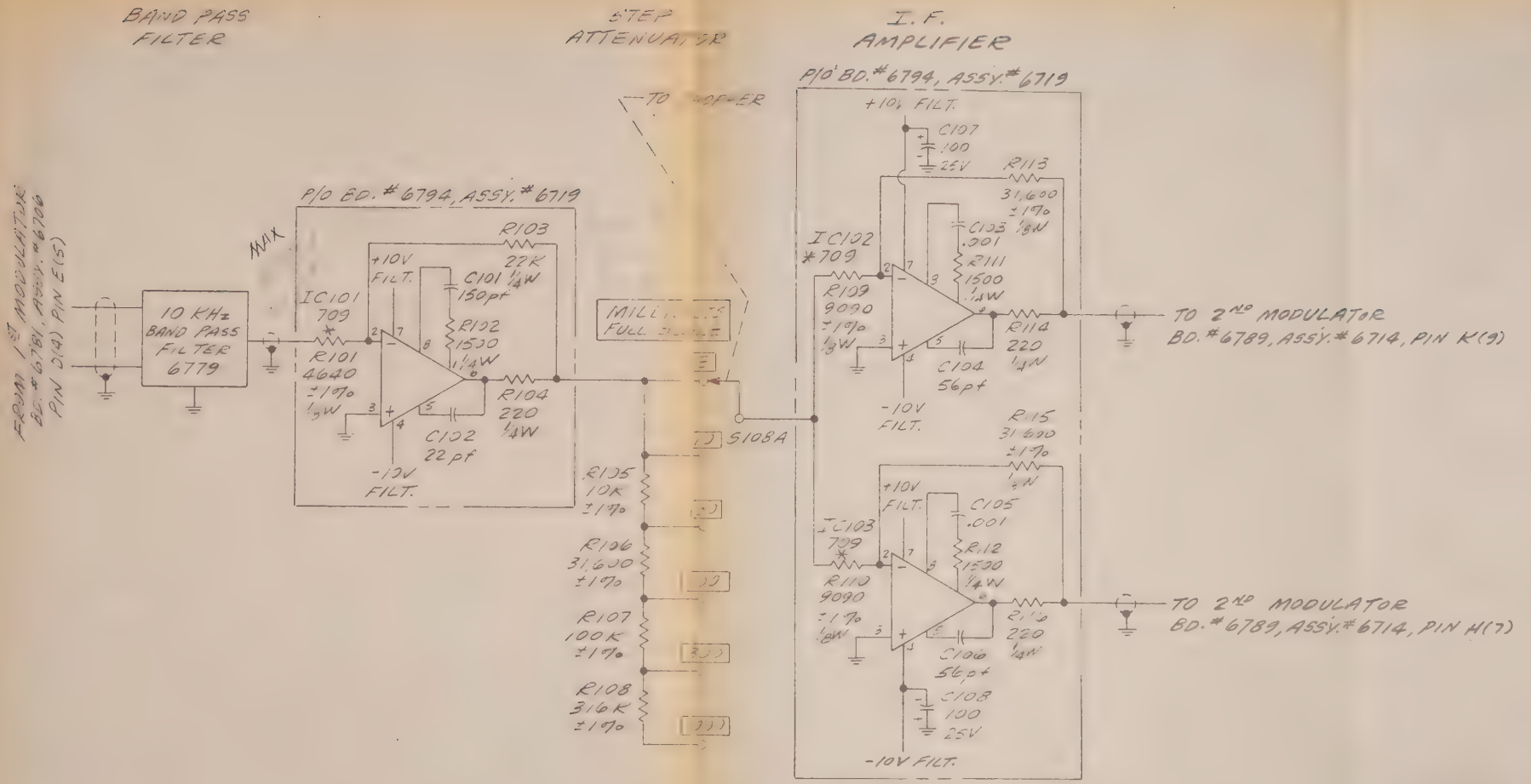
SCHEMATIC
LAMP CIRCUIT
MODEL 304-T
MODEL 304-TD

PRE-AMPLIFIER

BOARD # 6781, ASS'Y. # 6706

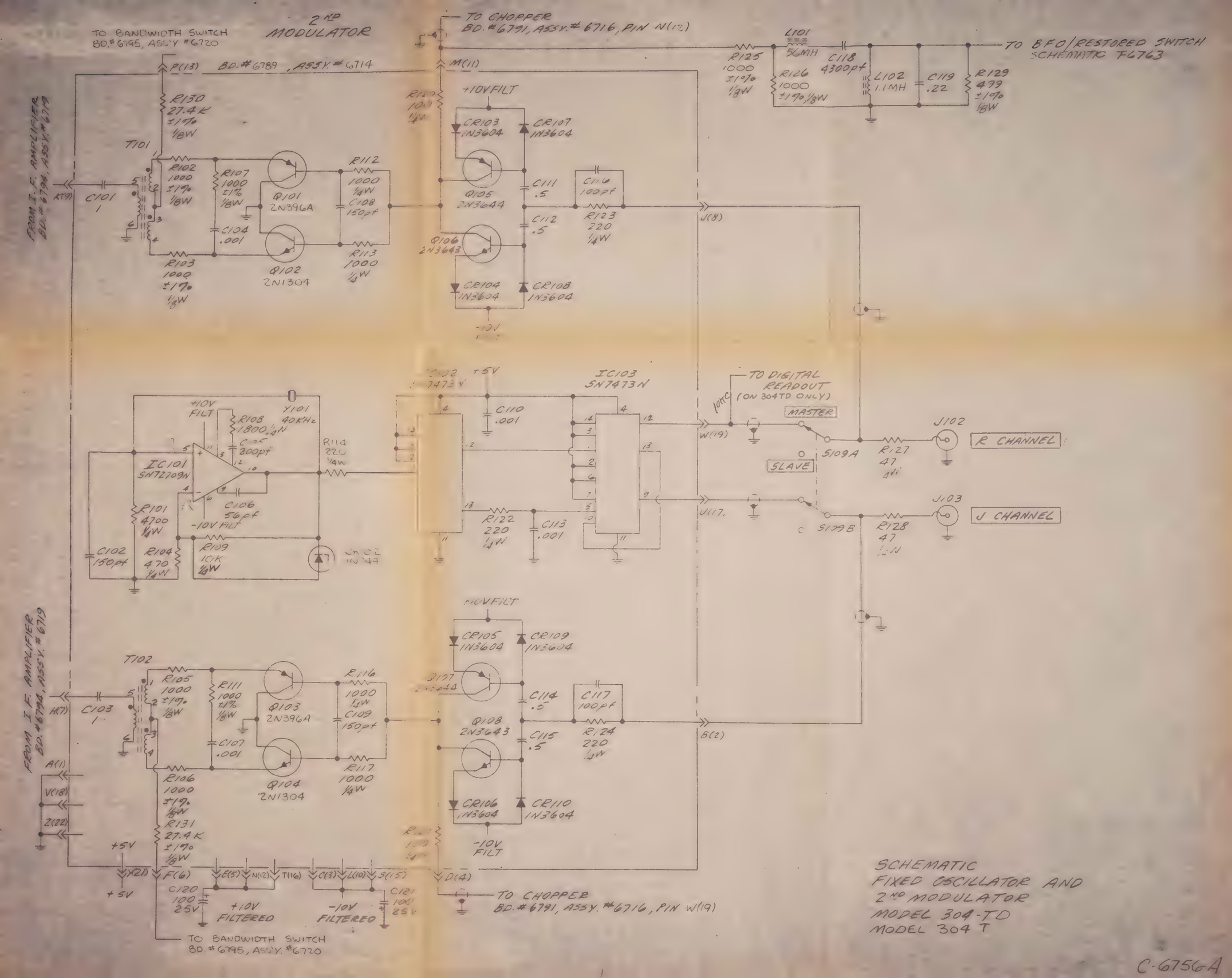


SCHEMATIC
INPUT, LOW PASS FILTER
PRE-AMPLIFIER AND
MODEL 304-T



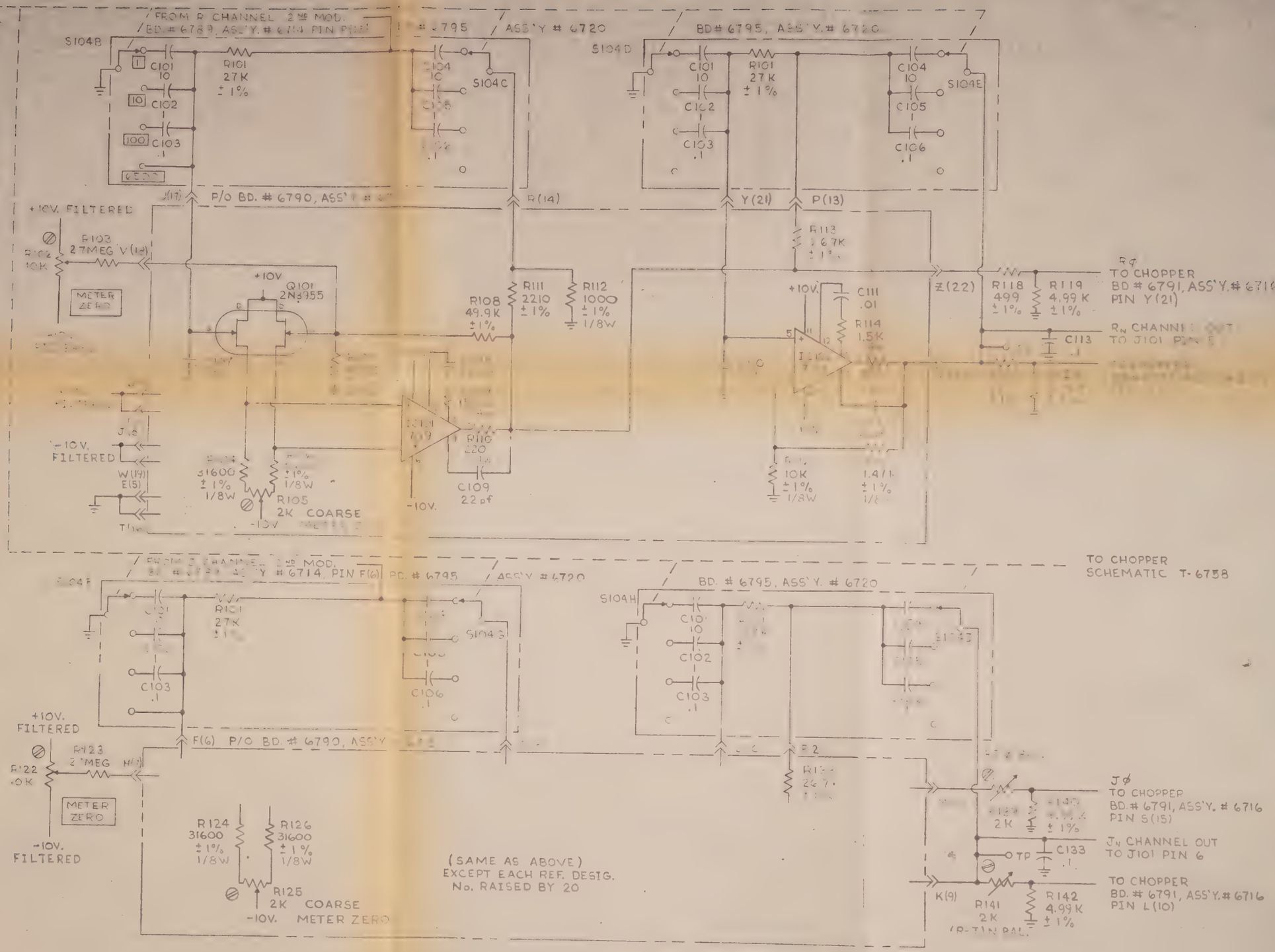
SCHEMATIC
BAND PASS FILTER, STEP ATTENUATOR
AND I.F. AMPLIFIER
MODEL 304-T
MODEL 304-TD

T-6755-A



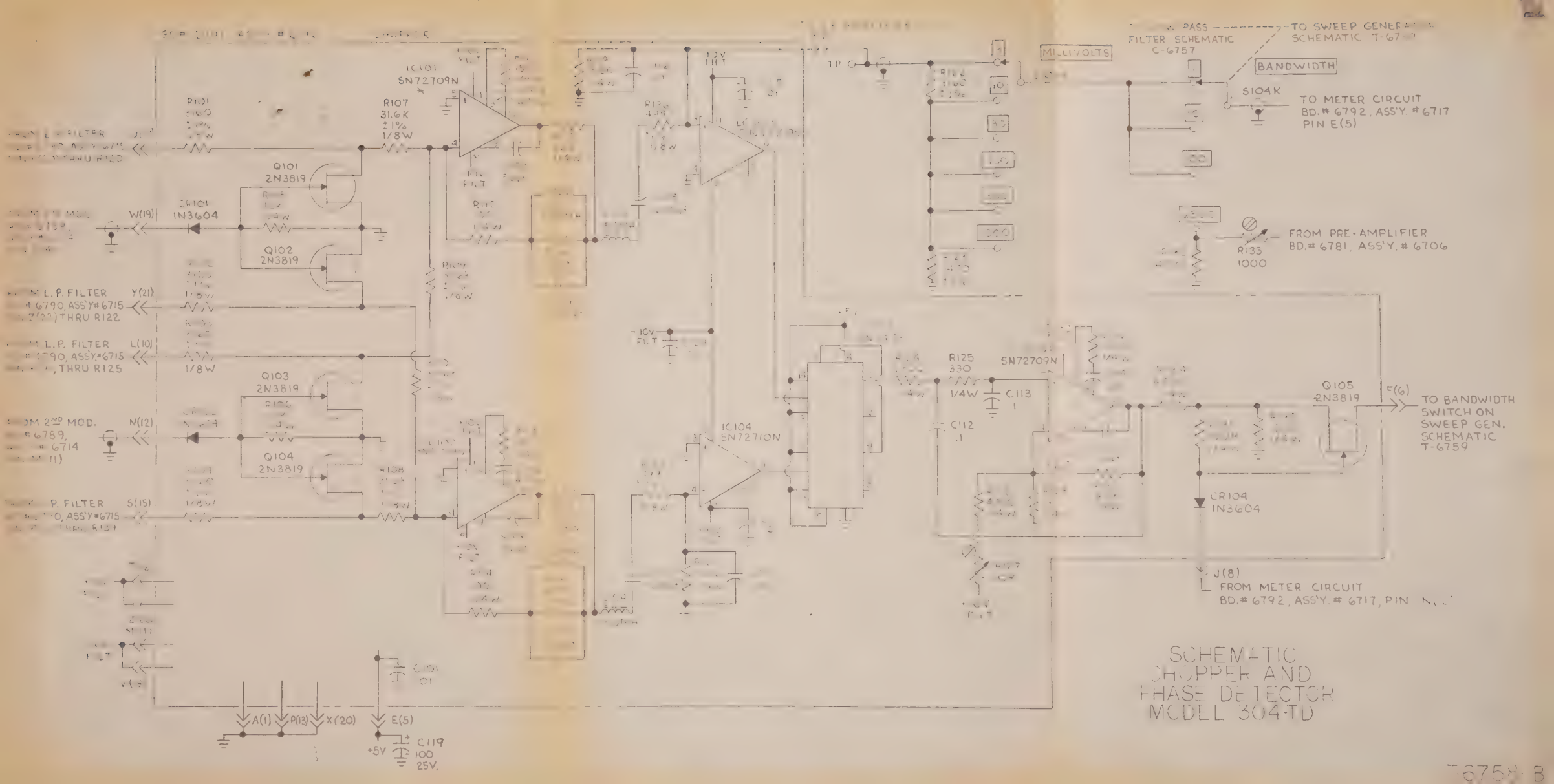
SCHEMATIC
FIXED OSCILLATOR AND
2ND MODULATOR
MODEL 304-TD
MODEL 304 T

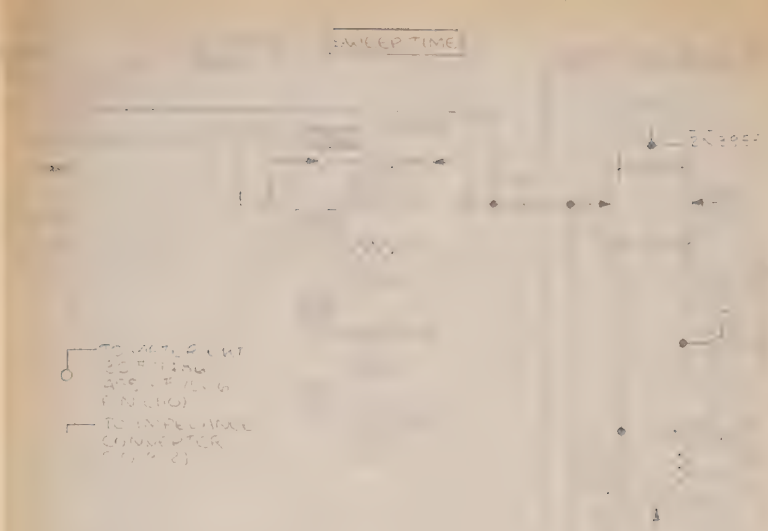
C-6756A

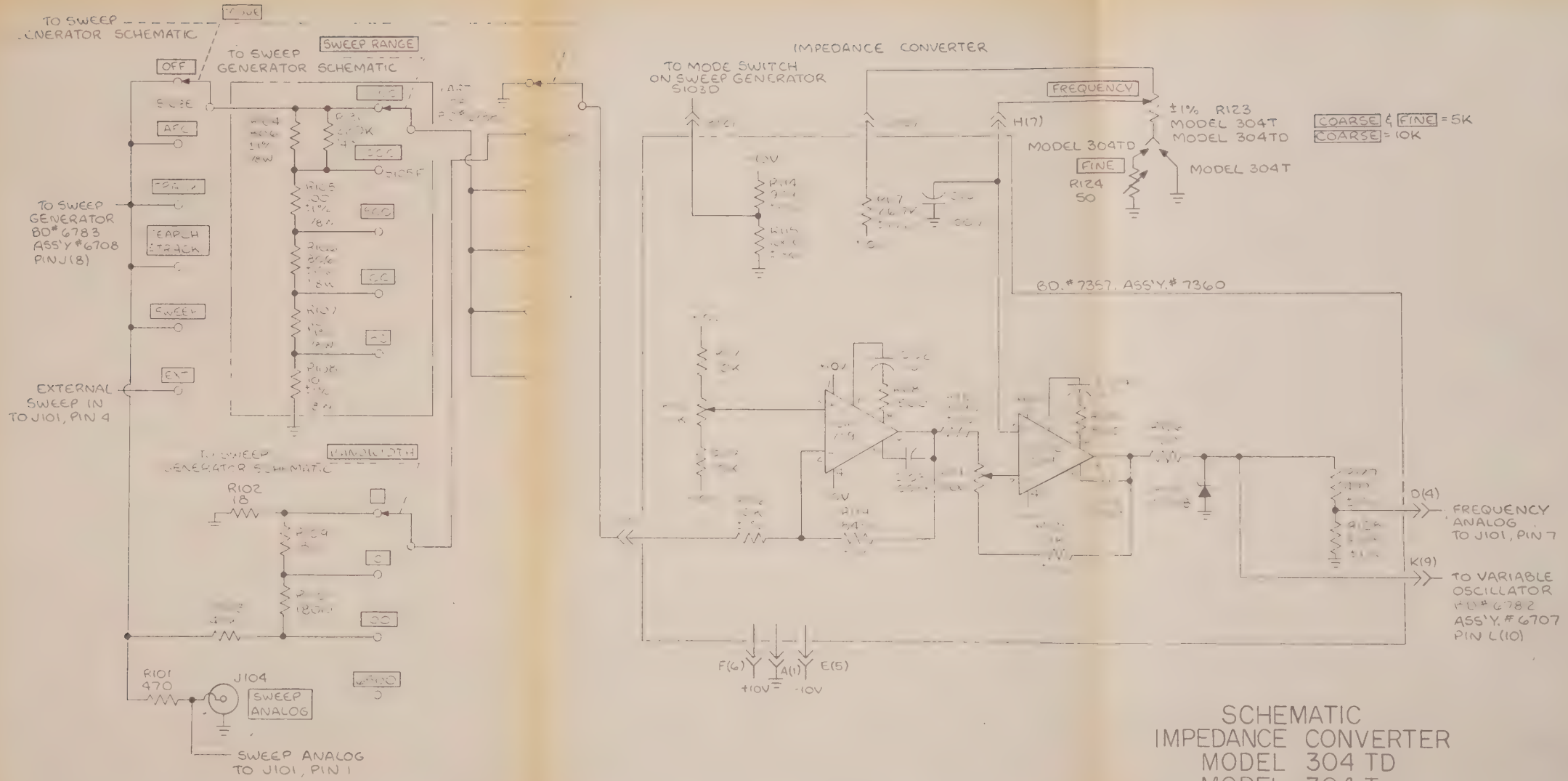


SCHEMATIC
LOW PASS FILTERS &
AMPLIFIERS
MODEL 304TD

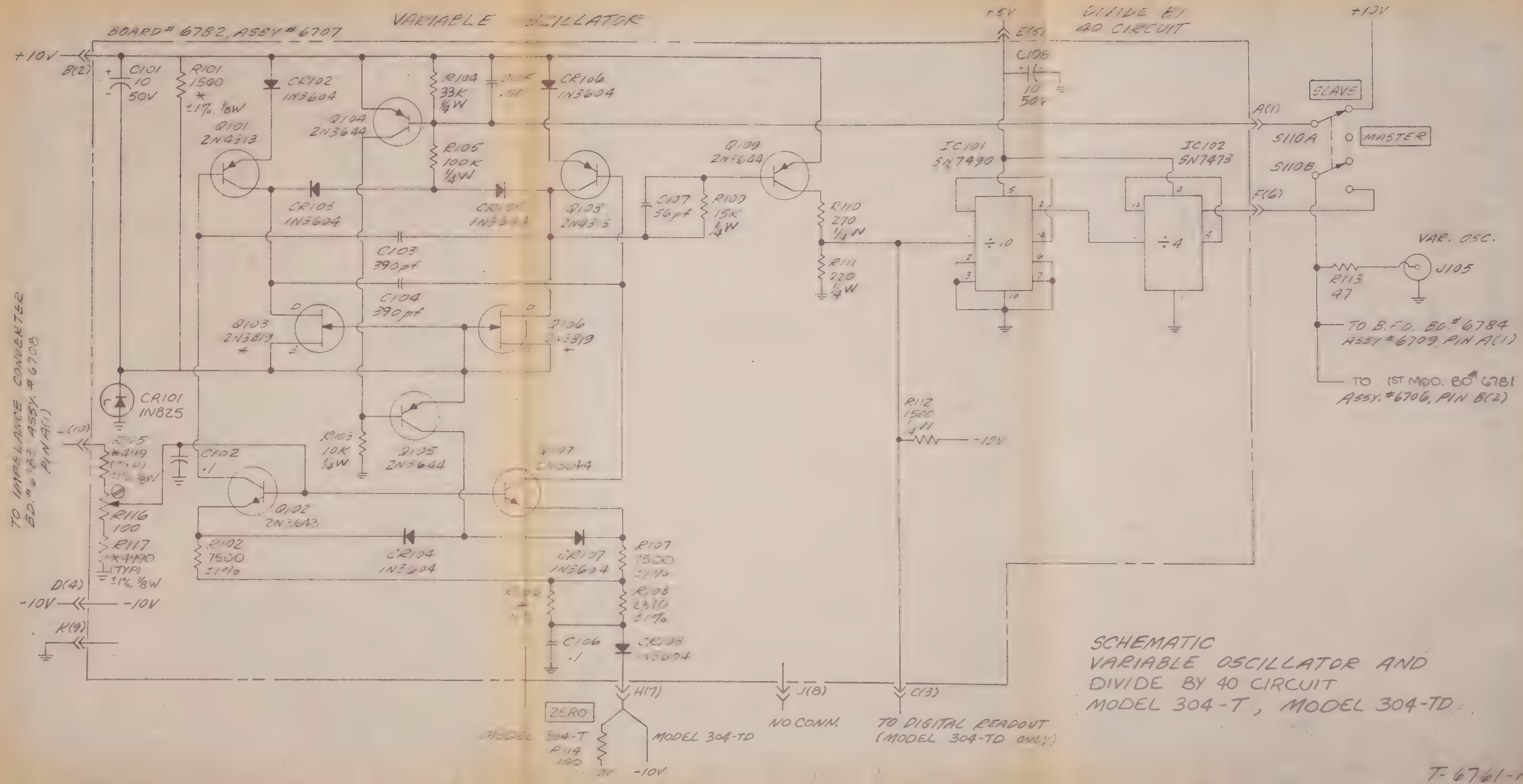
C-6757-A


IC101
SN72709N
R101
2160
±1%
1/8W
R107
31.6K
±1%
1/8W
Q101
2N3819
Q102
2N3819
Q103
2N3819
Q104
2N3819
CR101
1N3604
W(19)
Y(21)
L(10)
N(12)
S(15)
L.P. FILTER
#6790, ASS'Y #6715
THRU R122
THRU R125
2ND MOD.
#6789,
#6714
P. FILTER
#6790, ASS'Y #6715
THRU R123
IC104
SN72710N
R125
330
1/4W
C113
1
C112
.1
SN72709N
Q105
2N3819
F(6)
TO BANDWIDTH
SWITCH ON
SWEEP GEN.
SCHEMATIC
T-6759
CR104
1N3604
J(8)
FROM METER CIRCUIT
BD.# 6792, ASS'Y. # 6717, PIN
MILLIVOLTS
BANDWIDTH
S104K
TO METER CIRCUIT
BD.# 6792, ASS'Y. # 6717
PIN E(5)
FROM PRE-AMPLIFIER
BD.# 6781, ASS'Y. # 6706
R133
1000
TO SWEEP GENERATOR
SCHEMATIC T-6759
FILTER SCHEMATIC
C-6757
A(1)
P(13)
X(20)
E(5)
+5V
C119
100
25V.
C101
.01
SCHEMATIC
CHOPPER AND
PHASE DETECTOR
MODEL 304-TD


SWEEP TIME

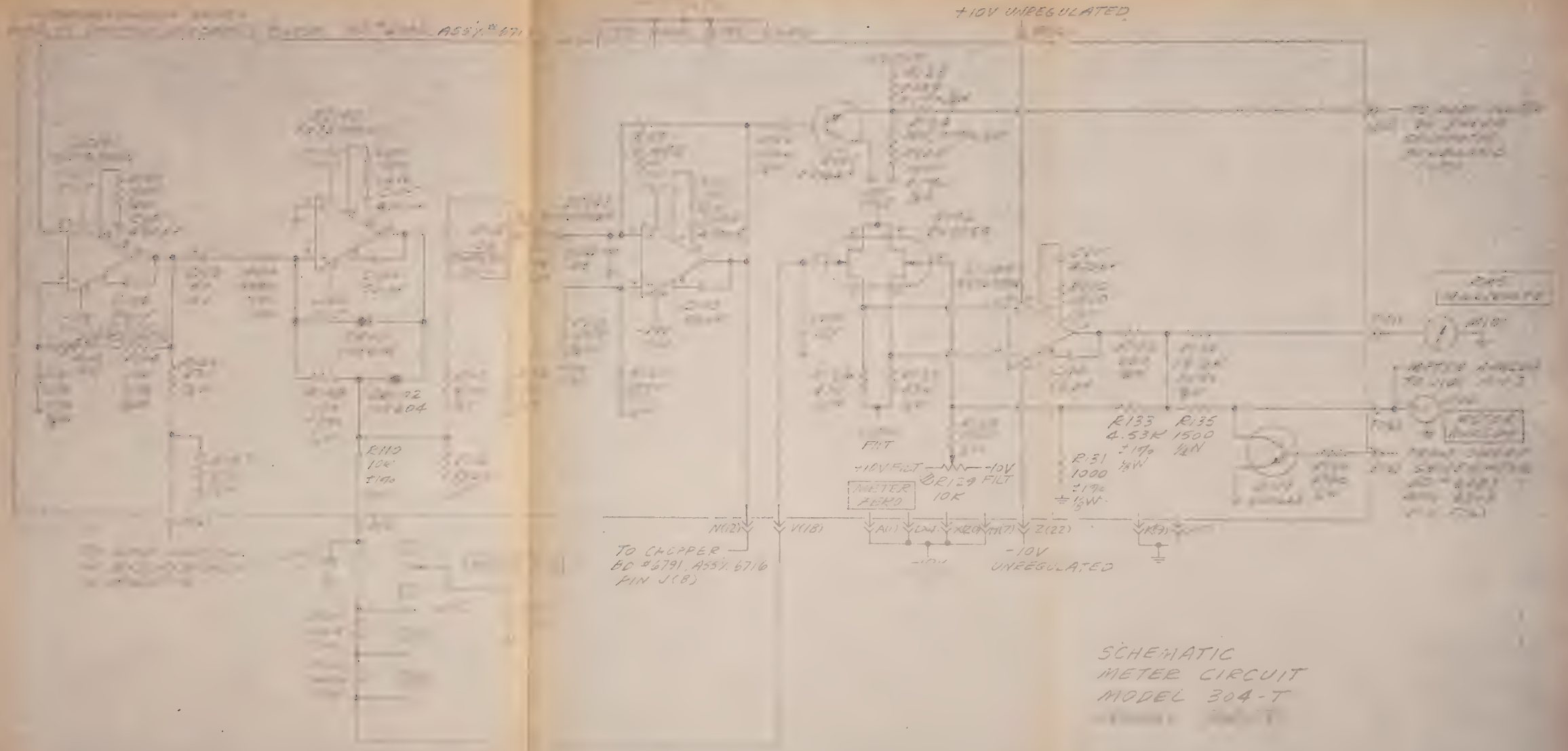


SCHEMATIC
IMPEDANCE CONVERTER
MODEL 304 TD
MODEL 304 T

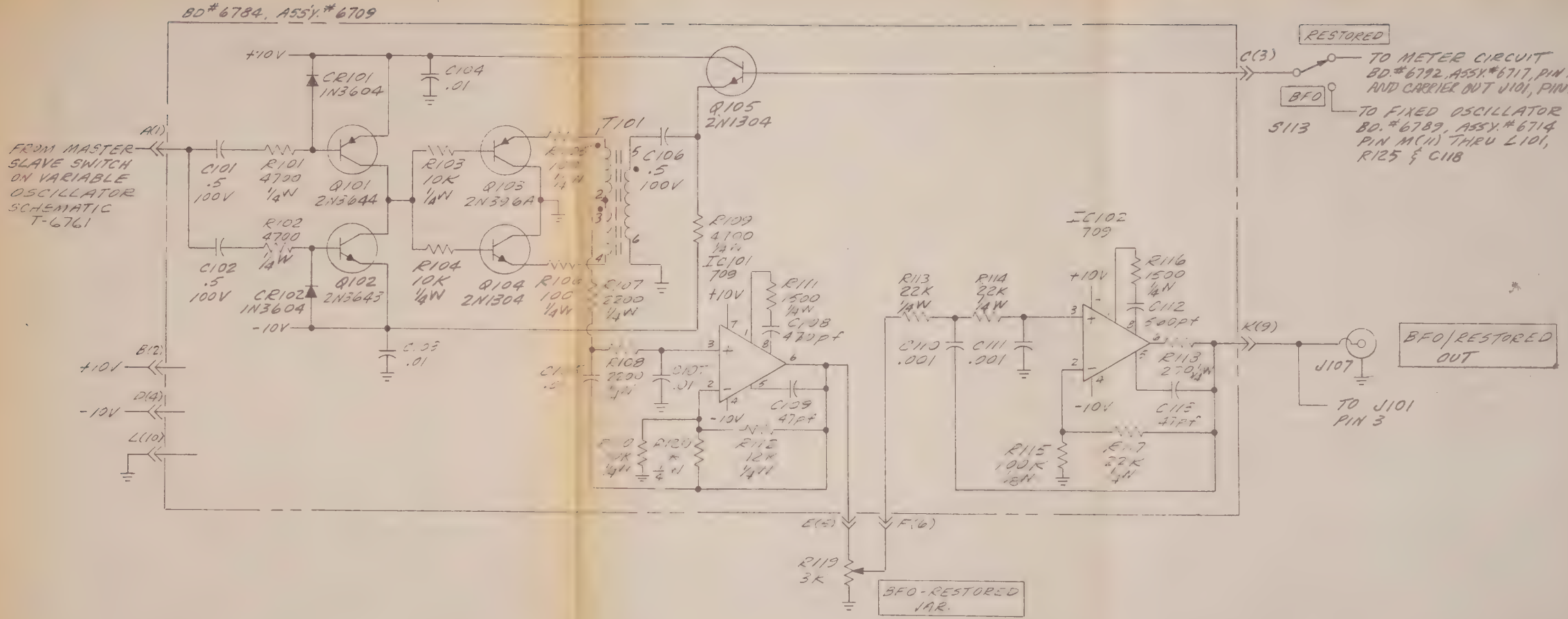


SCHEMATIC
VARIABLE OSCILLATOR AND
DIVIDE BY 40 CIRCUIT
MODEL 304-T, MODEL 304-TD

T-6761-H



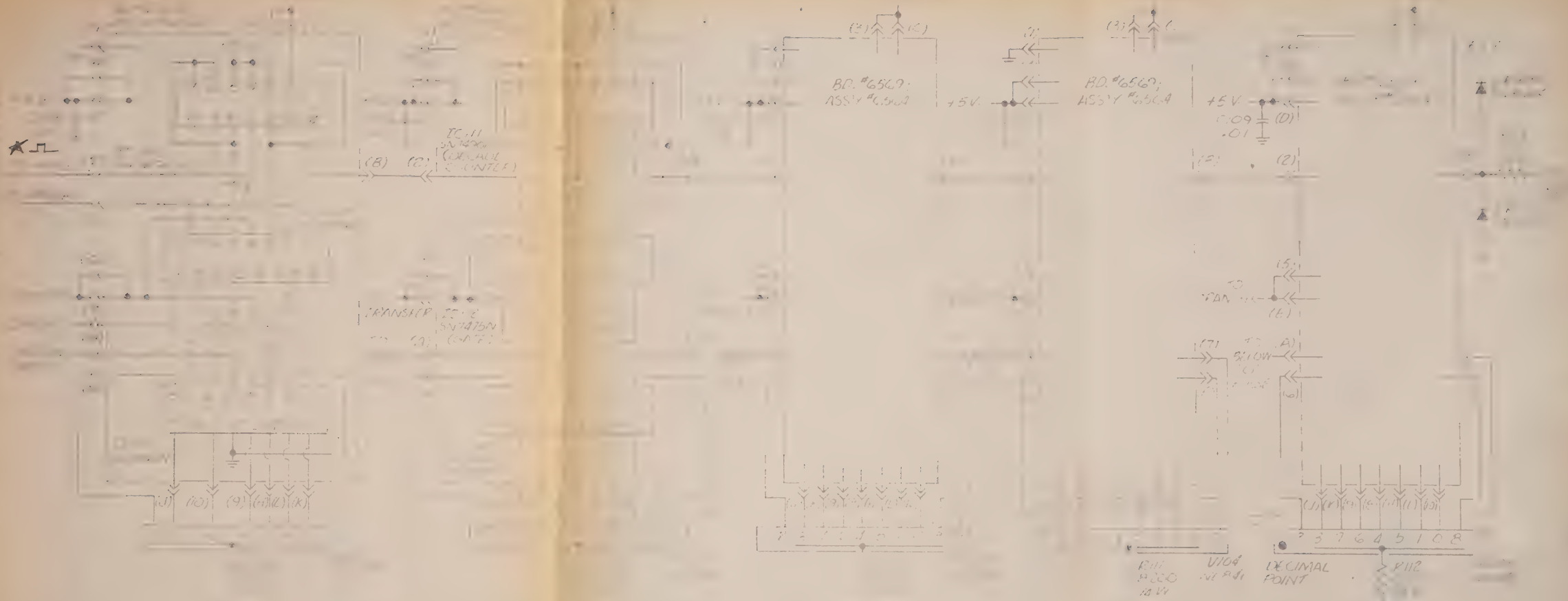
SCHEMATIC
METER CIRCUIT
MODEL 304-T



SCHEMATIC
BFO/RESTORED
MODEL 304-T
MODEL 304-TD

T-6763-A

SCHEMATIC
DIGITAL READOUT
MODEL [illegible]-TD


BD. #6569; ASS'Y #6569-A
+5 V.
BD. #6569; ASS'Y #6569-A
+5 V.
.09
.01
TO FAN
DECIMAL POINT
SCHEMATIC
DIGITAL READOUT
MODEL 338-TD

IMPORTANT

Notice to the User of this Instrument....Do you want to be kept up-to-date on measurement techniques, applications, and new instrumentation? Periodically Quan-Tech publishes technical papers and application notes that may increase the usefulness of your instrumentation.

We will be happy to add your name to this mailing list after receiving the attached prepaid postcard. The information we request will permit us to serve you better, and insure timely delivery of pertinent information.

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Quan-Tech®

INSTRUMENT RECORD

Manual registered on _ _ _ _ _ _ _ _

User's name _ _ _ _ _ _ _ _ _ _ _ _

Company _ _ _ _ _ _ _ _ _ _ _ _ _

Div./Dept _ _ _ _ _ _ _ _ _ _ _ _

Street _ _ _ _ _ _ _ _ _ _ _ _ _ _

City _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

State/Zip _ _ _ _ _ _ _ _ _ _ _ _

Instrument Record:

(Continued on other side)

Detach This Card First

INSTRUMENT REGISTRATION

Model No. _ _ _ _ _ _ _ _ _ _

Serial No. _ _ _ _ _ _ _ _ _ _

Options _ _ _ _ _ _ _ _ _ _

Company _

Div./Dept. _

Street _

City/State/Zip _

Name of User _

Title _ Telephone _ _ _ _ _ _

Instrument used in ☐Research/Development ☐Production/Manufacturing ☐Test/Quality Control ☐Service/Maintenance ☐Other _ _ _ _ _ _ _ _ _

Application _

_ _

_ _

May we contact you for comments or suggestions on this instrument/manual?

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Use This Card Only For Revision

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Serial No. _ _ _ _ _ _ _ _ _ _

Options _ _ _ _ _ _ _ _ _ _

Company _

Div./Dept. _

Street _

City/State/Zip _

Name of User _

Title _ Telephone _ _ _ _ _ _

Instrument used in ☐Research/Development ☐Production/Manufacturing ☐Test/Quality Control ☐Service/Maintenance ☐Other _ _ _ _ _ _ _ _ _

Application _

_ _

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May we contact you for comments or suggestions on this instrument/manual?

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